The Characteristics of Torrential Rain and Flood in China and the Countermeasures in Flood Control

By **LI Kungang**
The Office of the State Flood Control and Drought Prevention Headquarters

Many types of flood may happen in China, such as torrential-rain flood, snowmelt flood, glacial flood, ice-slush flood, dam-breach flood, etc. But so far as the whole country is concerned, it is the torrential-rain flood that brings the widest impact and the most serious harmfulness on the social and economic development. The flood disasters in the middle and lower reaches of seven large rivers of China are basically caused by torrential-rain flood.

I. Characteristics of the torrential rain and flood in China

1. Characteristics of the torrential rain

According to the stipulations by the Chinese meteorological sector, the rain with the daily rainfall of over 50 mm is called as torrential rain. The torrential rain in China has the characteristics of concentration in time and region, and high rainfall intensity.

(1) Concentration in time

The characteristics of concentration in time of the torrential rain in China are determined by the distinct continent monsoon climate. The torrential rain in China has obvious seasonal characteristics. In the region to the south of the Yangtze River, the rainy season is from April to July. But in the north, northeast and southwest regions of China, the rainy season is from June to September. The maximum four-month rainfall accounts for about 50%-80% of the total annual rainfall. The maximum one-month rainfall accounts for about 15%-30% of the total annual rainfall (See Table 1). The heavy torrential rain generally lasts one to seven days or even to nine days. The maximum one-month rainfall in a year is always concentrated in one torrential rain or several torrential rains.

(2) Concentration in region

The 50 mm isohyet of maximum mean annual 24-hour point rainfall value divides the Chinese continent into two parts with about equal area from Huma in Heilongjiang Province to Tengchong in Yunnan Province. In the west part of this isohyet, there is little torrential rain. The 100 mm isohyet goes from Liaodong Peninsular to the west along Yanshan Mountains, Taihang Mountains, Funiu Mountains, the southeast foot of Wushan Mountains to the south side of Yunnan-Guizhou Plateau. The east part of this isohyet belongs to the concentration distribution area of large-area torrential rain. Between 50 mm and 100 mm isohyets, it is mountainous plateau with over 1500 m above the sea level. Except the Sichuan Basin, the short-time local torrential rain mostly occurs in this region. (See Figure 1) From the 50mm and 100 mm isohyets of 24-hour point rainfall value, we can see there are three distinct high intensive torrential rain districts. The first is from Liaodong Peninsula to the coastal area to the south of Shiwan Mountains in Guangxi Automous Region. In this region, the daily rainfall exceeds 600 mm. The second is Yanshan Mountains, Taihang Mountains, the windward side to the east of Funiu Mountains, and Mufu Mountains, Dabie Mountains and Huangshan Mountains. The last three mountains are located in the middle and lower reaches of the Yangtze River. In this area, the daily rainfall can reach 600-800 mm. The third is the surrounding area of the Sichuan Basin in the upstream of Yangtze River. Its daily rainfall is usually between 400 mm and 600 mm (See Figure 2).

(3) High rainfall intensity

According to the analysis on the measured data, the measured maximum rainfalls in different duration in China are very close to the records of the world. Some investigated torrential rainfall amount even exceeds the record of the world (See Figure 3). There existed the rainfall of 53.1 mm in 5 minutes in Meidonggou of Taiyuan City in Shanxi Province in 1971, 240 mm in a half hour in Xiaoyeba of Datong County in Qinghai Province in 1976, 436 mm in 70 minutes in Tianju Village of Wushan County in Gansu Province in 1985, 830.1 mm in 6 hours in Linzhuang Village of Miyang County in Henan Province in 1975, 1672 mm in 24 hours in Xinliao in Taiwan Province in 1967, and 2050 mm in 7 days in Zhangma of Neiqiu

(4) Typhoon activities often cause high-intensity rainfall in a large area

In the southeast coastal region, there are seven typhoons annually. Therefore the torrential rain directly caused by typhoon is mainly distributed in the coastal region. In the central area of torrential rain, the rainfall of 800 mm in 2 or 3 days is not rare. Sometimes, the typhoon can also enter the inland area. If typhoon meets the cold air in the north region, it can cause the high-intensity rainfall in a large area and thus flood occurs. For example, the torrential rain occurred in Liaoxi in August of1930, in Haihe River basin in August of 1956 and in Huaihe River basin in August of 1975. All these torrential rains are related to typhoon (See Figure 4).

2. Characteristics of flood in China

The disastrous flood in China generally has four characteristics.

(1) The disastrous flood has high peak and large volume. According to the comprehensive analysis on the investigated and measured flood data from 6000 sections of river, the maximum flood discharge of rivers with different basin areas in China is very close to that in the world (See Figure 5). The amount of one large floodwater accounts for a high proportion of total runoff amount in the whole year. In terms of the rivers with the basin area of 10-15 thousand km^2, the ratio of flood amount in 7 days of one large floodwater to total runoff amount in the whole year are as follows. The ratio of Pearl River and Yangtze River basins is 10-20%, that of Songhua River basin 15-20%, that of Yellow River basin 20-25%, and that of Haihe River and Liaohe River 25-30%. The drier the climate is, the more concentration the runoff of the river. The total annual runoff amount in the middle rivers is concentrated in several floodwaters to a great extent.

(2) The serious flood disasters have certain similarity. According to the analysis on the historical data, in the main rivers, each extraordinary flood happened in the modern times can find the much similar example in the historical data. For instance, the serious flood in the south system of Haihe River basin in August of 1963 is quite similar to that in 1668. The flood in the north system of Haihe River basin in 1939 has

area in 1801. The floods in the middle and lower reaches of the Yangtze River and the Huaihe River basin in 1954 are also basically the same in causes and distribution areas as that in 1931. The flood in the middle reaches of the Yellow River in 1933 is similar to that in 1843. The large flood in the Yangtze River in 1998 also has many similar features to that in 1954.

(3) The floods in main rivers have certain time-sequence regularity. The high-intensity rainfall in large area is the key basic cause of the floods occurred in main rivers in China. The high-intensity rainfall in large area is closely related to the movement of the subtropical high-pressure belt in west of Pacific Ocean. In the normal years, the subtropical high-pressure ridge is situated between 15^0-20^0 northern latitude in the period from April to the beginning of June, and the torrential rain mainly happens in the Pearl River basin. From the middle of June to the beginning of July, the subtropical high-pressure ridge moves northward and pushes the rainfall belt to the Yangtze River basin and the Huaihe River basin. In the last twenty days of June, the rainfall belt moves to the Yellow River basin. From the last ten days of July to the middle ten days of August, the subtropical high-pressure ridge moves cross 30^0 northern latitude and the rainfall belt then covers the Haihe River basin, Hetao Plain and Northeast China. At this period, the tropical storms and typhoons frequently hit the South China to the south of the subtropical high-pressure ridge and thus cause the second peak of rainfall in this region. In the last ten days of August, the subtropical high-pressure ridge starts to withdraw from north to south. But if the subtropical high-pressure ridge moves abnormally and stays over a region for a long time, it will cause excessive and concentrated rainfall so that it causes serious flood and waterlogging disasters in that region.

(4) Main rivers have the characteristics of comparatively high water and low water periods. In the 1930's, main rivers are in the high water period. In this period, large floods happened in main rivers, except the Pearl River. In the 1940's, the inflow was small in main rivers so that no large flood occurred. During the period of the 1950's~1960's, main rivers entered a period with the frequent occurrence of flood. The large floods occurred in the Yellow River and the Huaihe River in 1954 and in the Songhua River in 1957. In the same way, the large floods happened in the Yellow

had caused serious disasters. During 10 years before and 15 years after the large flood happened in Huaihe River in 1975, no large flood in the whole basin had occurred in main rivers. Entering the 1990's, comparative large floods have occurred frequently in main rivers. The attention should be paid to such continuity of flood for the flood control.

II. Main problems of fighting against torrential rain and flood at present

Although a great number of works have been done in the aspects of fighting against torrential rain and flood for 50 years, there still exist many problems at present.

1. The flood surveying and dispatching support system is backward. The flood control departments are short of weather monitoring facilities, such as radar rainfall observation and cloud atlas receiving equipment. The data collect equipment of water regime in many hydrological station is outdated and damaged, and exceeds their service life. The application of remote sensing technology is not popularized. The computer data transmission network of flood control information in the whole country has not yet been set up. The forecast period of flood is not long. The forecast accuracy should also be further enhanced.

2. The capacity of flood control in rivers is low and there are more dangerous water works. Some projects determined in the flood control planning have not been carried out. The standard of many completed flood control projects is less than the stipulated engineering standard. At present, many main river dykes have only the standard of against 10-20 years flood under the condition that flood storage and detention basins are not used. 70% of the country's total cities still have not reached the stipulated flood control standards by the country. Even some cities have no flood control facilities. About 30% of large- and middle- sized reservoirs and 40% of small-sized reservoirs have dangerous engineering problems. At present, 50% of seawall for fighting against typhoon and sudden tide disasters have not reached the planning and designed standards.

basins are not completely carried out. The first is the imperfect of flood storage and diversion facilities. The second is that when flood is diverted, the population lived in the flood diversion basins is always temporarily shifted. The flood control planning is only designed to guarantee the safety of life but a few considerations on property safety are taken into account. The third is very few lifesaving appliances for masses in the flood diversion basin.

4. The sediment aggradation and bench reclamation cause the reduction of flood releasing capacity of river channel and flood storage capacity of lake. The serious water and soil erosion not only causes the silting up of sediment in rivers and lakes but also promotes the bench reclamation, which makes the storage capacity of lakes reduced rapidly and the flood releasing capacity of river channels decreased obviously.

5. The management measures of floodplain are weak and the system of flood insurance has not yet set up. Many flood storage and detention basins have not been used to divert flood for a long time. Because of the shortage of strong management measures, the population in such basins increases rapidly. The industrial structure also can not meet the needs of flood diversion and can not guarantee the safety of life and property in the region. Even as far as some rivers and reservoirs are concerned, their flood risk ranges and degrees are not so clear and concrete. At present, some test works of flood insurance of floodplain and flood control works are only developed as pilots. The comparatively perfect system of flood insurance has not set up and the flood insurance has not yet been developed in a large scale.

III. Measures of alleviating the torrential rain and flood disasters

Under the guidance of basin flood control planning, the concrete measures for fighting against torrential rain and flood shall be taken in various ways, such as flood forecast and survey, engineering measures, river dredge and flood diversion, management measures, command and dispatching system, flood prevention tools, etc.

1. Strengthening flood forecast and measurement

period should be extended. The satellite cloud atlas receiving system and radar rainfall detection system in flood control departments at different levels should be perfected. The real time monitoring on the disastrous weathers of torrential rain, typhoon and tropical storm should be carried out. The application of remote sensing technology should be speeded up and the monitoring means of disastrous flood should be improved. The computer network transmission of water regime data should be realized and the modernization level of real-time flood forecast should be raised. The flood-forecast period should be prolonged and the flood-forecast accuracy shoul be raised.

2. Strengthening the engineering measures in flood control

The comprehensive treatment of soil and water losses shall be conducted, taking the serious soil and water erosion regions in the upstream of the Yangtze River and the Yellow River as its key and the small watershed comprehensive treatment as its unit. Implement the unified planning of mountains, water, farmland, forest and grassland should be implemented. The arrangement of engineering measures, biological measures, water storage and soil conservation farming measures shall be carried out with the local actual conditions. The change of sloping farmland into terraced field shall be strengthened. The engineering standard of main flood control projects shall be properly enhanced and the weak positions of flood control projects shall be reinforced in order to increase the flood control capacity in the whole river basin and reduce the use opportunity of flood storage and detention basins whenever possible. The close attention should be paid to the treatment of the dangerous places and hidden perils of flood works such as dyke, reservoir, culvert and gate. The construction of the counterpart works for the flood control projects in key cities shall be speeded up in order to make such cities reach the state stipulated standards of flood control as soon as possible. The seawall construction can adopt the method of financial raising in many ways and at different levels to speed up the construction that meets standards concerned.

3. Strengthening the measures of diverting and retarding flood

The sound measures should be taken to clear away the flood releasing obstacles in the river channels. The dredge in river channel shall be scientifically verified in order to

seriously block the flood releasing should be cleared away, which should be combined with the construction of small towns to relocate the residents lived in such polders. If the polder surrounding lake affects flood releasing or seriously affects flood storage, it should be gradually removed in order to return it to lake. If the conditions allow, removing polder to release flood and returning polder to lake should be combined with the construction of flood storage and detention basins. The priority should be given to the construction of some key flood storage and detention basins. While constructing dykes and the embankments of safety area, some control structures of flood diversion shall be properly built. According to the actual conditions, the population lived in such basins should be relocated step by step. Through the construction of safety area and safety platform, the construction of lifesaving facilities for the masses in flood storage and detention basins should be speeded up. When the extraordinary flood happens, safeguard the flood storage and detention basins to divert and retard the flood timely and smoothly.

4. Strengthening the management measures of flood control

It should be strengthen the management of monitoring, warning and personnel shift in the regions where the mountainous disasters of flash flood, mud-rock flow and landslide frequently happen, in order to minimize the injury and death of the people. Work on the formulation of laws and regulations of “Management Regulation of Flood Storage and Detention Basins”, “Methods of Support and Compensation in the Operation of Flood Storage and Detention Basins” and “Compensation Methods of Materials Allocation in Flood Control” should be speeded up. The enforcement of laws and regulations concerned should be strengthened. The human activities that cause serious soil and water losses should be strictly controlled. The increase of the population in the flood storage and detention basins should be strictly limited and the industrial set up in the basins should be reasonably adjusted in order to meet the requirements of flood diversion. All activities that will affect the safety of flood control, such as constructing the water retarding structures and quarrying sand in river channel in violation of the rules should be strictly forbidden.

5. Strengthening the command and dispatching measures of flood control

The establishment of state flood control command system that covers all the key flood

provide flood regulation with the decision supporting tools in a rapid and flexible way and at different levels. The computer network and flood control communication network shall be set up to link the key flood control regions in the whole country. The data collection tools of flood control information of water regime, works conditions and disaster situation should be improved and change the data transmission ways and increase the speed of data collection and transmission in order to realize the sharing of data. The real-time flood monitoring and forecasting, real-time decision of flood dispatching schemes, and flood control consultation and demonstration tools in the flood control headquarters at the state, river basin organization and province levels should be improved and the flood forecasting and warning system in the flood storage and detention basins perfected.

6. Strengthening the flood control measures

Before the flood season, the following flood control preparatory schemes should be revised and decided: flood dispatching scheme, engineering prevention scheme, and personnel shift and settlement scheme in flood storage and detention basins. The flood control responsibility system of taking the chief administrator as the core and the persons at different positions in charge of different responsibilities should be carried out. The flood control goods and materials and flood control brigades at different levels should be well prepared. The technical training of flood control and emergency handling should be carried out. The various links of flood control projects and flood control preparations should be completely checked in order to timely deal with the discovered problems. The close attention should be paid to monitoring the weather changes and flood conditions during the flood season in order to timely study and take the concrete flood control measures in accordance with the flood situation. On the basis of flood control preparatory schemes, the technical personnel, local residents and army men should be organized to go on a tour of inspection of the flood control projects and to safeguard such projects. The flood control works of dyke, reservoir, and flood storage and detention basins should be reasonably used in order to scientifically regulate flood and timely resettle the people lived in the threatened area. The floodwater regime, engineering conditions and disaster situation should be mastered in order to do the post-disaster rehabilitation preparation work in advance.

Table 1 P[illegible]

China

Region	Mean annual rainfall (mm)	Percentage of maxi. mean annual 4-month rainfall to annual rainfall	Percentage of maxi. mean annual 1-month rainfall to annual rainfall
Haihe plain	600-800	More than 80	31
Songliao plain	400-800	70-80	26
Weihe plain of Yellow River basin	600-800	60-70	20
Middle and lower reaches of Huaihe River	800-1200	60-70	20
Lianghu plain of Yangtze River basin	1200-1400	50-60	18
Taihu plain	1100-1300	50	15
Downstream area of Pearl River	600-200	50-60	17

Figure 1. The isohyet map of maximum annual 24-hour point rainfall (mm) in China

Figure 2. The extremum distribution map of maximum 24-hour point rainfall in the east of China

Figure 3. Comparison of maximum rainfall in different duration in China with that in the world

Figure 4. The spatial distribution map of the large-range torrential rain in China

Figure 5. Comparison of maximum discharge in China with that in the world

Figure 6. Changes of the stage-discharge relation curve in the Shiguishan Hydropower Station in the Lishui River of Dongting Lake system